ELECTRON BEAM IRRADIATION AS A DECONTAMINATION METHOD FOR RICE PAPER SHEET

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Abstract

Starch is one of the most important plant products to man. The major sources of this compound for man's use are the cereals, but roots and tubers are also important. The starch industry comes in recent years growing and perfecting it self, leading to the necessity products with specific characteristics that take care the market requirements, it makes possible through processing raw material, still seldom explored. Rice paper is an edible product derived from potatoes and rice, being commonly used to cover cakes, pies, and sweets in confectioner's shop. A microbiological control is necessary to give a high quality and to guarantee the security of this food. Irradiation would be a safe alternative as a decontamination method without adverse effects on the physical properties in the final products. E-beam is recommended to treat sensible and thin slice food, because low energy is required. The aim of this study was to investigate the best dose used as a decontamination method as well as discover the most prevalent fungi found in this product and changes on physical properties. Samples of rice paper sheet were irradiated with 2.5, 5.0 and 10.0 kGy using an electron beam irradiator (Radiation Dinamics Co. model JOB-188, New York, USA).

I. INTRODUCTION

Starch is one of the most important plant products to man. The major sources of this compound for man's use are the cereals, but roots and tubers are also important. Starch in rice endosperm is composed of two different glucan chains, amylose and amylopectin. These polymers have the same basic structure, but differ in their length and degree of branching, which ultimately affects the physicochemical properties of these polymers with specific functionality[1].

Starch has been used in both food and non-food products for centuries. The starch industry comes in recent years growing and perfecting it self, leading to the necessity products with specific characteristics that take care the market requirements, it makes possible through processing raw material, still seldom explored. Rice paper sheet is an edible product made of starch, being commonly used to cover cakes, pies, and sweets in confectioner's shop[2].

Food irradiation has been successfully used to inactivate food spoilage microorganisms, including bacteria, moulds and yeasts. Filamentous fungi development in food and ration could result in toxins production, known as mycotoxins; mycotoxigenic fungi associated to food chain comprises basically three genera: *Aspergillus, Penicillium* and *Fusarium*[3,4,5].

Although irradiation is one of the most effective means to decontaminate dry food ingredients, widespread application for food preservation was not commercially implemented at that time mainly due to the consumer scepticism regarding the wholesomeness of the foods that are irradiated with gamma rays from radioactive isotopes such as ^{137}Cs or ^{60}Co. The application of electron beams accelerated mechanically to foods without using any radioactive source should change the consumer attitudes[6].

II. EXPERIMENTAL

II.A. Samples

Edible rice paper sheet were purchased from local retail market in São Paulo, Brazil. Each individual rice paper sheet consisted of an unique sample. This sample was fractioned under aseptic conditions in a set of 33 pieces (1x1 cm) which was placed into sterile Petri dishes, labeled and identified with its respective radiation doses. Five samples per dose were performed in triplicate.

II.B. Water Activity (*Aw*) Determination

Water activity (*Aw*) values from random samples were obtained using a Aqualab CX-2 device (Decagon Devices Inc.) with an accuracy of ± 0.003.

II.C. Irradiation

Samples were irradiated at IPEN-CNEN Electron Accelerator, a Dynamitron Machine (Radiation Dynamics Co. model JOB-188, New York, USA), with 0.842 MeV energy, scan 100 cm and support speed 6.72 m/min. Applied doses were 0 (control), 2.5, 5.0 and 10.0 kGy; dose rate was 5.61 kGy/s and electrical current 1.0 mA. CTA dosimeters were used for the radiation dose measurement.

II.D. Fungi Growth and Identification

After irradiation process, samples were placed over agar Sabouraud medium with chloranphenicol (0.01% w/v) plates. From a set of 33 pieces of sample, three agar Sabouraud medium plates containing 11 pieces (1x1cm) each were plated for each irradiation dose and incubated at 25ºC for 5 days, adapted from Berjak method [7]. Assay was performed in triplicate and results were expressed as fungal contamination percentage. Colonies from different morphological types were isolated in agar Sabouraud medium with chloranphenicol (0.01% w/v) and classified until genera.

II.E. Physical Assay

II.E.1 Burst Strength

A Texture Analyser (Stable Micro Systems Ltd., England, Model TA.XT2) with a 25 kg-capacity compression load cell and a 6 mm stainless steel cylinder probe (P/6) were used for burst strength measurement of rice paper samples in terms of Newton (N). Texture profile analysis was conducted with a test speed of 1.0 mm/s, until a 5.0 mm distance. All measurements were done in triplicate.

II.E.2 Color Measurement

The rice paper color was measured with spectrophotometer (Hunterlab, USA, Model ColorQuest XE). Twelve samples for each radiation dose were scanned to determine *L* (lightness), *a* (redness), and *b* (yellowness) values.

II.F. Statistical Analysis

Statistical analyses were developed using GraphPad Prism, 4.00 version, GraphPad Software for both tests. Differences between mean numbers were determined by analysis of variance, followed by the Dunnett test.

III. RESULTS AND DISCUSSION

Water activity (*Aw*) was measured for control and irradiated samples and values were around 0.56 at 25ºC. Considering it is an extremely dry product, little microorganisms could grow over it. Then filamentous fungi due to their resistance structures could stand in the product until favorable nutritional and physical conditions allow its development [8]. At present of use, an edible gel is applied by both side of paper and following is placed over cakes and pies. This procedure enables a significant increase in *Aw*, which reached values around 0.83 at 25ºC.

Fungal loads of control and irradiated samples of rice paper are shown in table 1. The initial fungal loads determined in non-irradiated samples were 18.18%. E-beam irradiation at 2.5 kGy and 5.0 kGy reduced this percentage almost two times fold, respectively to 12.12% and 6.06%. After irradiation to 10.0 kGy, no contamination was detected in these samples. Irradiation at low and medium doses (2.5 kGy and 5.0 kGy) was ineffective to promote total fungal decontamination. Although a 10.0 kGy irradiation dose completely inactivated fungal growth. Related to fungal contamination diversity, the most prevalent genera found were *Cladosporium* and *Penicillium*, respectively with 50% and 30%. The remaining contamination comprised of non-sporulated fungi (NSF). While *Cladosporium* spp. are just a food deteriorating micro-organism, *Penicillium* spp. could be produce mycotoxins depending on species and storage conditions. These mycotoxins, depending on the ingested amount could be harmful to human health, with carcinogenic or hepatotoxic properties [9,10].

Table 1. Percentage of fungal contamination and yellowness[a] (*b*-value) of rice paper.

Dose (kGy)	0	2.5	5.0	10.0
(%) Fungal Contamination	18.18%	12.12%	6.06%	0.0%
Yellowness (*b*-value)	1.93 ± 0.04c	2.49 ± 0.06d	2.96 ± 0.04d	3.73 ± 0.08d

[a] Mean±standard deviation(n=12). Values followed by different letters have a significative difference by Dunnett test ($P<0.05$).

Rice paper color changed from white to yellow after irradiation. Increasing radiation doses resulted also in an increase of yellowness (*b*-value) (Table 1). The b-value of non irradiated rice was 1.93. After irradiation, even the lowest dose (2.5 kGy) differed significantly to control with a value of 2.49. A significant increase was detected ranging from 2.96 to 3.73, respectively for 5.0 kGy and 10.0 kGy. Few studies were performed with irradiated rice paper sheet, however some authors such as Sirisoontaralak and Noomhorm (2006) and Roy et al. (1991) have already reported color changes in gamma irradiated rice. Some studies suggested that yellowing would be due to breakdown of glycosidic and peptidic linkages promoted during irradiation (breakdown products such as carbonyl and amino compounds react - Maillard reaction - and then colored compounds are formed), as well as melanoidins formed due to phenols oxidation [12].

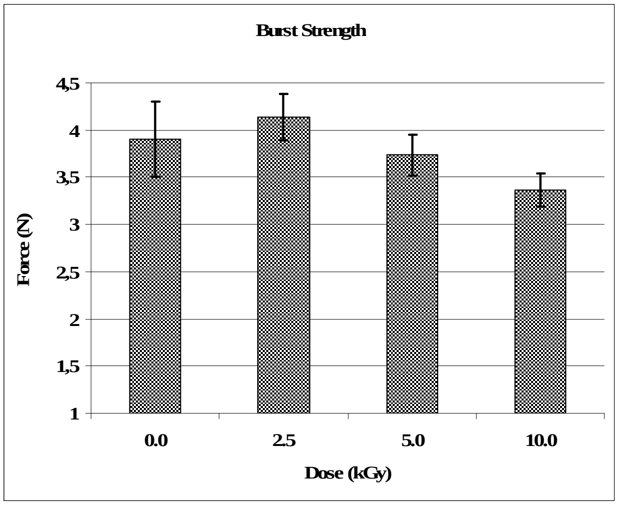

Figure 1. Influence of different radiation doses on burst strength of rice paper sheet.

Burst strength measurement detected slightly differences between control and irradiated samples (Figure 1). Mean values for rice paper burst strength were: 3.90 ± 0.40 N, 4.14 ± 0.25 N, 3.74 ± 0.22 N and 3.36 ± 0.17 N, respectively to control, 2.5 kGy, 5.0 kGy and 10.0 kGy. Only samples irradiated with 2.5 kGy showed a significant difference to control related to burst strength ($P<0.05$). In general, increasing radiation doses promoted a decrease in the measured force. Sung (2005) have also already reported a firmness decrease of rice curd due to gamma irradiation. Even so, irradiation process did not change negatively this property with a dose necessary to promote total fungal decontamination.

IV. CONCLUSION

As a result from this study, we concluded that e-beam irradiation could be used as a successful decontamination method assuring total fungal elimination. Some adverse changes in physical characteristics were found. Burst strength remained similar under the conditions assayed and color measurement indicated a significant difference among control and those irradiated with doses over 2.5 kGy. An intermediate dose between 5.0 kGy and 10.0 kGy could also reach the same satisfactory effect in terms of fungal control, reducing processing costs and preventing undesirable changes on physical features.

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